2 Description of Wachusett Watershed Resources

2.1 Wachusett Watershed Ownership and Land Use

Land use and development patterns in a watershed also influence the hydrology and water quality of its streams and lakes/reservoirs, and are important considerations to determine the appropriate protection measures for the watershed. The following sections detail current land uses and the protection status of watershed lands.

2.1.1 Current Land Uses

Land cover, land use and population density for the Wachusett, Quabbin, and Ware watersheds are shown on Table 1 and a land cover, land use map is presented in Figure 2. Although the watershed system is sparsely developed, the level of developed land is lowest in the Quabbin watershed and becomes more developed and populated eastward to the Wachusett watershed. No wastewater treatment plants or industrial discharges exist within any of the three watersheds.

TABLE 1. LAND COVER, LAND USE, AND POPULATION DENSITY OF MDC WATERSHEDS

Land Cover / Land Use by %, Excluding Reservoir Surface Areas				
	Quabbin Reservoir	**Ware River**	**Wachusett Reservoir**	**Combined**
Forest	87	75	67	77
Wetland	6	11	8	8
Agriculture	3	5	8	5
Residential	1	3	9	4
Commercial/ Industrial	0.1	0.2	0.6	0.3
Open Water	0.3	3	2	2
Other	3	4	7	4
Persons per sq.mi.	16	77	284	109

Source: MDC, MWRA, and CDM (1997)

TABLE 2. WACHUSETT RESERVOIR WATERSHED LAND OWNERSHIP AND LAND COVER / LAND USE

	MDC		**Other EOEA**		**Other Protected**		**Total Protected**		**Private**		**Total**	
	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%
Forest	12,458.3	17.6	3,111.0	4.4	5,213.3	7.4	20,782.6	29.4	26,392.7	37.3	47,175.3	66.7
Wetland	1,640.3	2.3	256.4	0.4	583.7	0.8	2,480.4	3.5	2,936.0	4.1	5,416.4	7.7
Agriculture	899.4	1.3	347.1	0.5	176.6	0.2	1,423.1	2.0	3,970.8	5.6	5,393.9	7.6
Residential	75.7	0.1	7.8	0.0	24.2	0.0	107.7	0.2	6,081.7	8.6	6,189.4	8.7
Com/Ind	24.9	0.0	1.3	0.0	13.3	0.0	39.5	0.1	746.6	1.1	786.1	1.1
Open Water	351.1	0.5	83.7	0.1	1,012.7	1.4	1,447.5	2.0	162.5	0.2	1,610.0	2.3
Other	1,042.7	1.5	44.4	0.1	634.3	0.9	1,721.4	2.4	2,474.5	3.5	4,195.9	5.9
Total	16,492.4	23.3	3,851.7	5.4	7,658.1	10.8	28,002.2	39.6	42,764.8	60.4	70,767.0	100.0

FIGURE 2. LAND COVER, LAND USE MAP

go to www.state.ma.us/mdc/WachusettLMPfig2.pdf (file size: 1.4 MB)

The main land cover in all watersheds are forests and wetlands, totaling 75% in Wachusett, 93% in Quabbin, and 86% in Ware. The largest land uses are residential and agriculture. Residential land use is mostly low density and is most extensive in the Wachusett watershed, where housing density tends to be greater near the town centers. Commercial and other land uses (highways, recreation, and waste disposal) are less significant in the watersheds. The present commercial areas tend to be located near the town centers and along major roads. In the Wachusett watershed, the subbasins most developed are Scarlett, West Boylston, and Gates. These subbasins are located in the southeastern part of the watershed, along Gates Brook and West Boylston Brook.

In 1997, Comprehensive Environmental inventoried agricultural sites for DWM. These sites include dairy/ livestock farms (varying from several medium-size dairy farms to sites with two to ten animals), grazed land (pastures where livestock roam), and a variety of crop farms (orchards, truck crops, field crops, nurseries, Christmas tree farms). Collectively, most of the dairy/livestock farms in the watersheds are small, with many hobby farms and residential properties with horses.

2.1.2 Protected Lands

Overall, the MDC owns and/or directly controls about 42% of the entire watershed system, exclusive of the reservoirs themselves. MDC owns approximately 57% of the Quabbin watershed, 37% of the Ware River watershed and 26% of the Wachusett watershed (Table 3). Other state agencies, non-profit land conservation organizations and municipalities own and protect another 21% of the combined watersheds. Figure 3 shows the MDC-owned and other protected lands in the watersheds.

TABLE 3. MDC AND OTHER PROTECTED OPEN SPACE

	Open Space as % of Watershed*		
Watershed	MDC-Owned	Other Protected**	Total Protected
Quabbin Reservoir	57	18	75
Ware River	37	20	57
Wachusett Reservoir	26	26	52
Combined	42	21	63

* Watershed area excluding reservoir surface.
** Includes lands owned by other state agencies, local government, and private entities.

FIGURE 3. MAP OF MDC OWNED AND OTHER PROTECTED LANDS IN THE WATERSHED.

go to www.state.ma.us/mdc/WachusettLMPfig3.pdf (file size: 1.8 MB)

2.2 Physical Characteristics of Wachusett Lands Under MDC Control

2.2.1 Geology

2.2.1.1 Regional Context and Bedrock Geology

A 1992 MWRA report by Geologist David Ashenden states: "Massachusetts is a part of the northern Appalachians which consist of a variety of rock types ranging from slightly deformed sedimentary rocks to those that have been severely deformed and metamorphosed. Numerous igneous intrusions are also included. The rocks range from Late Precambrian to Early Mesozoic in age. The area is the product of several orogenies involving plate accretion during the Paleozoic. Since that time prolonged erosion has removed literally thousands of feet of rock exposing the roots of old mountains. Locally younger and less deformed rocks are present primarily in the Connecticut valley and along the coastal plains."

At least three major geological blocks, delineated by fault lines, intersect the watershed: the Nashoba block or terrane, the Merrimack block or trough, and the Kearsarge-Central Maine synclinorium. The farthest east of these is the Nashoba block, consisting of volcaniclastic rocks and granitoid intrusions. The Cosgrove Aqueduct falls almost entirely within the Nashoba block. Heading west, the Nashoba is separated from the Merrimack block by the Clinton-Newbury fault. The Merrimack block (also known as the Merrimack trough) consists primarily of quartz-rich metamorphic rocks, and includes the Ayer Granite intrusions of the Oakdale Formation. The Ayer Granite has been aged at approximately 433 million years old, placing the Oakdale Formation as not younger than the Early Silurian period of the Paleozoic era. The next block to the west appears to be the Kearsarge-Central Maine synclinorium, although the contact between this block and the Merrimack has not been well defined, and may be obscured by the granites of the Fitchburg Plutonic Complex. These granites intruded between these two blocks at least 30 million years after the formation of the Ayer Granite.

Within the Merrimack block, there are three formations of note in the Wachusett Reservoir area: the Tower Hill, Oakdale, and Worcester Formations. The Tower Hill Formation consists of fine-grained quartzite and phyllite. The majority of the Oakdale Formation is finely laminated interbedded siltstones, but also includes quartzite, calcareous quartzite, siltstone, calcareous siltstone, and schist. The Worcester Formation is comprised of pelitic and aluminous phyllite, granulite, and schist. Of these formations, the Oakdale is the most extensive rock unit.

2.2.1.2 Surficial Geology

The Wachusett Reservoir watershed has been subjected to repeated glaciation, which has resulted in the creation and mixing of till deposits formed by the tremendous erosional power of glacial ice. The Ashenden report describes the presence of at least two layers of glacial tills on the watershed, the lower till, also referred to as drumlin till, and the upper till, which is ground moraine. The drumlin till is the core of true drumlins and some of the local hills near Wachusett Reservoir, and is considered to have occurred before the most recent (Woodfordian) glacial advance. The retreat of the Woodfordian glaciers occurred about 10-11,000 years ago, and left an upper till of ground moraine. Where the Woodfordian glaciers eroded the edges of the drumlin till, there was also mixing of the lower and upper tills. In the uplands, the thickness of the tills ranges from zero where bedrock is exposed to many feet in thickness.

In the valleys, these tills are covered by outwash sands and gravels, which have altered the drainage characteristics of these areas and have direct effects on vegetation types.

2.2.2 Soils

In the Wachusett watershed, the predominant soils found are Hinkley-Merrimack-Windsor, Paxton-Woodbridge-Canton and Chatfield-Hollis. Additional soil types are found in the upper watershed, including soils in the Peru, Marlow, Montauk, Ridgebury, and Whitman series, as well as Bucksport and Wonsqueak mucks. Many of these soils are well drained to excessively well drained, including the Hinkley-Merrimack-Windsor soils on outwash plains, and the Canton and Chatfield-Hollis soils on uplands. These soils occur on gently sloping to moderately steep areas and are very deep, except for Chatfield-Hollis soils, which typically have a depth to bedrock of only a few feet. Other soils are poorly drained, including the Paxton-Woodbridge, Peru, Marlow, Montauk, Ridgebury and Whitman soils, as well as the Bucksport and Wonsqueak mucks. The permeability of most of these soils is limited by a substratum present a few feet below the surface, except for Bucksport and Wonsqueak mucks, which are organic soils. Some of these soils occur in depressions and low flat areas in uplands and frequently contain water, including the Ridgebury, Whitman, Bucksport, and Wonsqueak soils. Others occur in gentle to strongly sloping areas throughout the watershed, including the Paxton-Woodbridge, Peru, Marlow, and Montauk soils.

The soils in the Wachusett, Quabbin, and Ware watersheds appear to have a low to moderate erosion potential. The predominant soils in the Wachusett watershed, for instance, have K factors ranging from 0.10 to 0.32 out of a possible range of 0.03 to 0.69, where higher values indicate higher erosion potential. Thus, soil erosion is only likely to be a problem in areas where slopes are greater than 15% or where vegetation has been disturbed. Because the great majority of the watersheds is forested and has slopes less than 15% (82% of the total watershed and 86% of the Wachusett Reservoir watershed), the extent of erosion prone areas is limited.

In the Wachusett watershed, areas with higher erosion potential are located near much of the Stillwater River; on Rowley, Ross, and Justice Hills in Sterling; and on much of the land south of Route 110 near the reservoir. Erosion has only been significant in a few of these locations: the area affected by the 1989 tornado, where vegetation was severely disturbed, and the steep bluffs on the east shore of the reservoir, where steep slopes coincide with thin vegetation and strong winds. (Revegetation and slope protection techniques have been used in these locations to reduce erosion.) No significant problems have occurred on erosion-prone areas that border tributaries.

According to the USDA Natural Resource Conservation Service, most soils in the Wachusett, Quabbin and Ware watersheds are not well suited for the disposal of wastewater through septic systems. Many soils that are well drained to excessively well drained tend to drain effluent too quickly to effectively filter it. On the other hand, soils that are poorly drained are not well suited for leach fields because they have slow permeability and water is usually present near the surface.

2.2.3 Hydrology

The hydrology of a watershed plays an important role in defining the water quality characteristics of its streams and lakes/reservoirs. The following sections describe the morphology of the reservoirs; the precipitation, evaporation, and streamflow patterns in the reservoirs watersheds; and the inflows and outflows and hydrodynamic characteristics of the reservoirs.

Figure 1 shows the watersheds of the Quabbin and Wachusett Reservoirs and the Ware River. The Sudbury Reservoir, located further east on the distribution system, is maintained as a backup emergency supply. The Quabbin and Wachusett Reservoirs receive the natural inflows of direct precipitation onto the reservoir surface, tributary rivers and streams (including baseflow, shallow subsurface flow, and saturated overland flow) and of overland flow from storm or snowmelt events. The Ware River may be diverted on a seasonal basis to Quabbin Reservoir through the Quabbin Aqueduct. Wachusett Reservoir, the terminal water supply reservoir, receives substantial transfers on an intermittent basis from Quabbin Reservoir.

2.2.3.1 Morphology

Wachusett Reservoir is a long and narrow reservoir. Morphometric characteristics (measurements of form and shape) of the Wachusett Reservoir are shown in Table 4.

TABLE 4. MORPHOMETRY OF WACHUSETT RESERVOIR

Attribute	Wachusett Reservoir
Volume Capacity	65 billion gallons
Surface Area	6.2 sq. mi.; 3,968 acres
Watershed Area	117 sq. mi.; 74,880 acres
Shoreline	37 miles
Length	8.5 miles
Maximum Width	1.1 miles
Mean Width	0.7 miles
Maximum Depth	128 feet
Mean Depth	49 feet
Normal Operation Range[1]	387-392 feet
Intake Depth	364 & 345 feet
Overflow Elevation	395 feet

[1]Datum used is Boston City Base (or 5.65 feet lower than USGS 1929 datum used for topographic mapping).

2.2.3.2 Precipitation and Evaporation

Annual precipitation is about 44 inches in the Wachusett watershed (MDC, MWRA, and Rizzo Associates, 1991b; MDC, MWRA, and Rizzo Associates, 1991a). Annual potential evapotranspiration in central Massachusetts has been estimated between 22 and 28 inches (Thornthwaite *et al.*, 1958). While evaporation measured with an evaporation pan is about 39 inches in Massachusetts (Higgins, 1968), evaporation in lakes and reservoirs is usually lower. Annual evaporation in Wachusett Reservoir has been estimated as 22 inches (Brackley and Hansen, 1977), and more recently, as 24.5 inches (FTN, 1995). Monthly rainfall in the Wachusett watershed is nearly uniform, although it can vary significantly from year to year. Summer precipitation generally comes in high-intensity thunderstorms. Table 5 presents the ranges and averages in monthly precipitation for Wachusett Reservoir.

TABLE 5. MEAN MONTHLY PRECIPITATION AT WACHUSETT RESERVOIR

Month	Wachusett Reservoir (1897-1979)		
	Minimum (inches)	Maximum (inches)	Average (inches)
January	0.75	12.08	3.92
February	0.36	8.69	3.66
March	0.06	1.04	4.22
April	0.86	10.67	4.02
May	0.62	10.75	3.76
June	0.48	12.01	3.88
July	0.84	9.47	3.87
August	0.80	13.31	3.87
September	0.15	11.09	3.85
October	0.09	10.83	3.60
November	0.86	9.03	4.28
December	0.75	9.36	4.03

Source: MDC, MWRA, and Rizzo Associates (1991a, 1991b)

2.2.3.3 Streamflow

Streamflow in the Wachusett watershed, as in most of New England, has significant seasonal changes. Flows tend to be highest in the spring, due to snowmelt and high groundwater; and lower in the summer and early fall. These seasonal changes are important since high flow water quality threats (streambank erosion) tend to occur in the spring, whereas low flow water quality threats due to lower dilution (higher bacteria levels) tend to occur in the summer and early fall.

In addition, streamflow also varies in response to rainfall events. According to the Wachusett Reservoir Water Quality: Interim Assessment (CDM, 1995b), stormwater flows in the Wachusett tributaries tend to be several times higher than baseflow and the magnitude of loading during stormwater conditions tends to dwarf that during baseflow conditions. Furthermore, time of travel from the upper reaches of the watershed to the reservoir tends accelerate during stormwater conditions. Time-of-travel maps for baseflow and stormwater conditions are currently being developed as part of the Wachusett

Watershed Stormwater Management Plan (CDM, 1998). Preliminary results show that baseflow stream velocities during the early summer (June) are about 0.3 ft/s, while in the spring (March-April) baseflow stream velocity ranges between 0.4 and 2 ft/s.

DWM is currently studying the influence of groundwater levels on streamflow in the watershed. Groundwater level data has been collected since 1996. Preliminary results show that high groundwater typically occurs for an extended period in the spring and in spikes during the fall, and that there is a strong relationship between high groundwater and increased baseflow in the tributaries. In areas to be sewered, these results will be used in conjunction with future monitoring to assess the impact that sewering will have on tributary baseflows.

2.2.3.4 Inflows and Outflows

Inflows and outflows to Wachusett Reservoir are listed in Tables 6 and 7. Tributaries to Wachusett Reservoir were not gauged until 1994. Since then, continuous recording gages have been installed in the Stillwater and Quinapoxet Rivers, and eight staff gages have been installed in other tributaries by the USGS for DWM. Because of the limited tributary flow data, streamflow records for the tributaries were synthesized using flows gauged in nearby rivers and streams and were transposed based on the flow per unit watershed area. FTN Associates (1995) describe the method. Average flows recorded since 1994 at the new gage locations agree well with those derived from the synthesized streamflow records.

MDC transfers from Quabbin Reservoir account for over 50% of the average annual Wachusett inflow. Transfers of up to 550 million gallons per day (mgd) are made as needed to maintain the Wachusett Reservoir surface levels and for water quality reasons. These transfers, which occur primarily in the summer and fall months, are not continuous and last for a period of several weeks at a time.

Inflows from Wachusett Reservoir's main tributaries, the Stillwater and Quinapoxet Rivers, account for another 30% of the average annual inflow. The remaining inflows originate in several small subwatersheds or flow directly into the reservoir from shoreline areas and groundwater inputs.

T. Kyker-Snowman

Tributary inflow

TABLE 6. INFLOWS TO WACHUSETT RESERVOIR

	Area (sq.mi.) [1]	Annual Flow (cfs)[2]	Annual Flow (mgd)[2]	% Annual Flow
Inflows:				
Quabbin Reservoir Transfers	149	235	152	51
Quinapoxet River	56	84 [3]	54 [3]	18
Stillwater River	32	65	42	14
Gates Brook	3	7	5	1.3
French Brook	2	4	3	0.9
Malagasco Brook	1.1	2	1	0.5
Malden Brook	1.3	3	2	0.6
Waushacum Brook	8	16	10	4
Direct Inflow	9	19	12	4
Direct Precipitation	6	22	14	5

TABLE 7. OUTFLOWS FROM WACHUSETT RESERVOIR

	Area (sq.mi.) [1]	Annual Flow (cfs)[2]	Annual Flow (mgd)[2]	% Annual Flow
Outflows:				
Cosgrove Aqueduct	NA	411	266	92
Spillway	NA	24	16	5
Evaporation	6	11	7	2
Other Outflows [4]	NA	9	6	2

1 Areas obtained from MDC, MWRA, and Rizzo Associates (1991b).
2 Inflows, outflows, and evaporation were estimated for 1987, 1990, 1992, and 1994 during the modeling study by FTN (1995). Values presented are averages for the years that were included in this study. Tributary inflows were estimated by gage transposition. MDC transfers from Quabbin Reservoir and outflows were obtained from MDC records. Evaporation was estimated using CE-QUAL-W2. Cosgrove Aqueduct outflows have declined, since this data set, to about 240 mgd.
3 The Quinapoxet River contributes less flow than its drainage area would suggest, since water from 36% of its drainage area is diverted to the City of Worchester's reservoirs and is only released to the Quinapoxet River during periods of high flow.
4 Other outflows include Clinton and Wachusett Aqueduct withdrawals and downstream releases.

The largest outflow from Wachusett Reservoir is the Cosgrove Intake withdrawal, which accounts for more than 90% of the water leaving the Reservoir. Other outflows from the Reservoir include flow through the Reservoir's spillway (which occur when the reservoir is full or almost full), evaporation and other minor outflows (Clinton withdrawals, Wachusett Aqueduct withdrawals at the dam, and downstream releases to the Nashua River).

2.2.3.5 Hydrodynamics

The basic hydrodynamic characteristics of Wachusett Reservoir include the following:

- Moderate to long residence times, defined as the reservoir volume divided by the annual inflows. Residence time at the Wachusett Reservoir is about 6 months, although this would double to about one year if Quabbin flows were not diverted into the reservoir.

- Wachusett Reservoir is a dimictic lake, turning over or mixing completely between fall overturn (usually in October) and the spring onset of stratification (usually in April).

- The Reservoir develops some ice cover, usually between January and March, but occurring as early as December or as late as April.

- Inflows tend to move into different depths at the reservoir depending on seasonal temperature differences between the tributaries and the reservoir. Tributary inflows will typically be warmer than the reservoirs in the spring and enter the reservoirs' epilimnion[1], and cooler than the reservoirs in the summer and fall and enter the reservoirs below the epilimnion. MDC transfers from Quabbin Reservoir into Wachusett Reservoir typically enter at the top of the hypolimnion.

- The hydrodynamics of Wachusett Reservoir were the subject of an extensive study by CDM and FTN Associates (CDM, 1995a; CDM, 1995b; FTN, 1995)[2]. This study made some important findings:

- Thomas Basin is an important feature of the reservoir, helping to preserve high water quality. The basin is separated from the main body of the reservoir by the Route 12 causeway, which constricts the width from approximately 1,000 feet to just over 50 feet. Most of the inflow to Wachusett Reservoir (about 90%) passes through Thomas Basin, including Quabbin transfers and Stillwater and Quinapoxet River inflows. Under normal tributary flow conditions (non-storm and Quabbin not transferring), the residence time in the basin can be on the order of several weeks. Even when Quabbin is transferring, the residence time in Thomas Basin is about 4 days, a sufficient period of time to allow the settling of solids present from the tributaries. Thus, Thomas Basin is an effective sedimentation basin for inflowing solids and their adsorbed contaminant load (*e.g.*, nutrients, bacteria, and possibly pathogens). While the turbidity of the inflowing streams is already low, the reduction of solids load (estimated to be about 85 to 90% of entering solids) certainly contributes to the high quality of water in the main body of the reservoir.

- Large inflows, including Quabbin transfers and storm flows from the main tributaries, can travel through the reservoir more quickly than would be expected from its residence time (about 6 months).

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[1] Stratified lakes are described as having three zones: the upper epilimnion, the metalimnion, forming a boundary between waters of different temperature; and the bottom hypolimnion.

[2] These studies were conducted as part of the MEPA process for the MWRA► s Walnut Hill Water Treatment Plant and underwent substantial public and citizen advisory committee review.

The hydrodynamic model for Wachusett Reservoir was used to estimate travel times to the intake during the stratified period for Quabbin transfers and Stillwater River stormflows with and without wind-induced transport. Quabbin transfers were estimated to reach the intake in 10 to 15 days. With winds in the prevailing direction, storm flows from the Stillwater River, when residing on the reservoir's surface waters, were estimated to reach the intake in 10 to 15 days, and in 28 to 30 days without wind. Tributary storm flows are more likely to reside in the reservoir's surface waters in the spring, when their water is warmer than the reservoir. Wind tends to accelerate the transport of these flows because the prevailing wind direction is down the long axis of the reservoir.

- Small inflows into the main body of the reservoir, including storm flows from smaller tributaries (such as Gates, French, Malagasco and Malden Brooks) tend to mix with the reservoir's water and not reach the intake as defined flows because they have insufficient volume and momentum to move through the reservoir.

- Quabbin transfers during the stratified period undergo limited mixing as they move through the reservoir and retain a distinct signature centered at elevations 355 and 360 feet Boston City Base (BCB) at the Cosgrove Intake. Because the intakes are located at 340 and 360 feet BCB, much of the water withdrawn when transfers are occurring is diluted Quabbin water.

- Withdrawn water at Wachusett Reservoir appears to originate from the epilimnion/metaliminion rather than the metalimnion/hypolimnion due to the presence of a submerged cofferdam. Wachusett Reservoir has intakes at two different depths, 360 feet BCB and 340 feet BCB. While the lower intake at 340 feet BCB is the only one currently operated, measured outflow temperatures are warmer than those predicted by the hydrodynamic model at this depth, matching those predicted by the model at elevation 360 feet BCB. This difference appears to be caused by the presence of a submerged cofferdam, used during construction of the intake building but not removed. The cofferdam appears to function as a weir, causing water drawn by the intake to be effectively drawn from higher in the water

2.2.3.6 The Quabbin "Interflow" in Wachusett Reservoir

The transfer of water from Quabbin to Wachusett Reservoir via the Quabbin Aqueduct has a profound influence on the water budget, water column profile characteristics, and hydrodynamics of the Wachusett Reservoir. During the years 1995 through 1999, the amount of water transferred annually from Quabbin to Wachusett ranged from a volume equivalent to 44 percent of the Wachusett basin up to 90 percent. The period of peak transfer rates generally occurs from June through November. However, at any time of the year, approximately half of the water in the Wachusett basin is derived from Quabbin Reservoir.

The peak transfer period overlaps the period of thermal stratification in Wachusett and Quabbin Reservoirs. Water entering the Quabbin Aqueduct at Shaft 12 is withdrawn from depths of 13 to 23 meters in Quabbin Reservoir. These depths are within the hypolimnion of Quabbin Reservoir where water temperatures range from only 9 to 13 degrees C in the period June through October. This deep withdrawal from Quabbin is colder and denser relative to epilimnetic waters in Wachusett Reservoir. However, due to a slight gain in heat from mixing as it passes through Quinapoxet Basin and Thomas Basin, the transfer water is not as cold and dense as the hypolimnion of Wachusett. Therefore, Quabbin water transferred during the period of thermal stratification flows conformably into the metalimnion of Wachusett where water temperatures and densities coincide.

The term interflow describes this metalimnetic flow path for the Quabbin transfer that generally forms between depths of 7 to 15 meters in the Wachusett water column. The interflow penetrates through the main basin of Wachusett Reservoir (from the Route 12 Bridge to Cosgrove Intake) in about 3 to 4 weeks depending on the timing and intensity of transfer from Quabbin. During the summer stratification period, the Quabbin interflow is conspicuous in profile measurements as a metalimnetic stratum of low conductivity. The interflow essentially connects Quabbin inflow to Cosgrove Intake in a "short circuit" undergoing minimal mixing with ambient Wachusett Reservoir water.

2.2.4 Topography

Mainly hilly, the topography of the Wachusett watershed encompasses flatter wetlands and flood plains, as well as mountainous terrain with exposed bedrock. The Wachusett watershed includes broader valleys and more wetlands than the watersheds further west. Elevations vary from 395 feet above sea level at Wachusett Reservoir to about 2,000 feet at Wachusett Mountain. 14% of Wachusett watershed, in widely scattered areas, contains slopes greater than 15%.

2.2.5 Developed/developable Areas

Excluding the reservoir, 75% (53,250 ac) of the Wachusett watershed is under forest or wetland cover, and 8% (5,680 ac) is under agricultural land uses. 52% of the watershed (excluding the reservoir surface) is currently protected, either through direct ownership by the MDC (26%) or other state/town agencies, or through protected status provided by private entities or regulations (e.g., Watershed Protection Act).

48% of the Wachusett watershed (excluding the reservoir) is "unprotected," i.e. available for development. Most of the undeveloped land is currently zoned for low density residential uses (1-2 acre minimum lot size). Commercial and industrial zoned lands represent a very small proportion of the watershed, and tend to be located near the town centers and major roads. No major development in the watershed is expected to occur in categories such as waste disposal, recreation, or major highways. Thus, future development in the watershed is expected to involve the gradual conversion of forested land into low-density residential land.

The cumulative amount of development that is expected in the watersheds is much lower than the current amount of available unprotected land. The rate of development depends on many social and economic factors, including development pressure, the need or willingness of current owners to sell their land, and population growth. For example, looking at the next 20-year period, projected population increases in the main towns within the Wachusett watershed (Boylston, West Boylston, Holden, Princeton, and Sterling) range from 5 to 26%.

Through its land acquisition program, MDC has purchased both undeveloped and developed lands in the Wachusett Reservoir watershed. Some types of developed properties that have been purchased include houses, a former gas station on Route 12 in West Boylston, gravel pits, and the Stillwater Farm located on Route 140 in Sterling. In addition, the former Metropolitan District Commission Police Station on route 70 in Clinton was kept by the agency after the police force was disbanded. There are numerous facilities and structures, along with other developed areas on the 16,000 acres that make up the MDC lands on the Wachusett Watershed. Some of these facilities are currently in use (e.g., the old stone church in West Boylston, as an interpretive site), while others are slated for removal (e.g., the concrete bathhouse in Clinton).

2.2.6 Other Open Lands

2.2.6.1 Recreational Fields

The town of West Boylston is permitted to utilize 10.3 acres of MDC land for recreational purposes. Located on either side of Thomas St. in West Boylston, the area is comprised of a softball field, a tennis court, a small basketball court and an open grass area used for a variety of purposes including youth soccer.

2.2.6.2 Fields/Non-forest

MDC owns approximately 953 acres of open upland scattered throughout the Wachusett Reservoir watershed and an additional 40 acres of fields outside of the watershed. There are approximately 270 acres of open wetland on MDC land in the watershed.

2.3 Wachusett Forest and Wildlife Conditions

2.3.1 Forest History

The landscape that confronted the Metropolitan Water Board in 1897, when work began on the construction of the Wachusett Reservoir, was very different from the Wachusett landscape today. Photographs from this time show wide open expanses of field and pasture with widely spaced pockets of forest visible from one end of the reservoir to the other. Farms and mills dominated the industry in the area. Forested land accounted for about 43% of the initial acreage (1,475 of 3,380 acres) taken by the MDC to construct the Wachusett Reservoir. Much of this land was occupied by young forest that originated with farm abandonment following the Civil War. The idea that forests are the source of high quality water was becoming ever more accepted during this time. New York set a precedent when it began in 1883 setting aside 1.25 million acres in the Adirondacks for the "preservation of the headwaters of the chief rivers of the state."

Once the decision was made that the newly acquired land, above the level to which the waters would rise behind the dam, should be covered in trees, the next decision would regard the character of this new forest. The fourth annual report of the Forestry Division of the United States Department of Agriculture stated in 1880:

> It is clear…that the influence of the forest, if any, will be due mainly to its action as a cover, protecting the soil and air against insolation and winds. That the nature of a cover, its density, thickness, and its proper position has everything to do with the amount of protection it affords, everybody will admit. A mosquito-net is a cover, so is a linen sheet or a woolen blanket, yet the protection they afford is different in degree and may become practically none…Just so with the influence of the forest; it makes all the difference whether we have to do with a deciduous or coniferous, a dense or open, a young low or an old high growth, and what position it occupies with reference to other elements, especially to prevailing winds and water surfaces.

Given that the forestry profession was in its relative infancy in this country, it was perhaps inevitable that the vision that the early managers had of a proper, organized forest would be based more on the European model of plantations rather than modeled on the far more complex character of the indigenous mixed-species forest. A Forestal Plan was developed that called for the creation of a road network, fire guard lanes and planting schemes. Plans were drafted as early as 1897 for "The Suggested Arrangement of Trees for Re-Foresting the Margins of the Wachusett Reservoir." Record Plans were created at a scale of 1"=300' that were ideal for recording tree planting. Two nurseries were established in 1898 to supply planting stock. Planting began in 1902. In the end, four and one-half million trees were planted from 1902 to 1946 (see species composition in Table 8). To the credit of the planners during this time, a remarkably wide variety of species were planted.

TABLE 8. PLANTING BY MDC, BY SPECIES, 1902-1946

Species	Percent of Total Planted	Species	Percent of Total Planted
White Pine	58%	Spruces	7%
Sugar Maple	14%	Arborvitae	5%
Red Pine	13%	All others	3%

78% (nearly 3.5 million) of all trees planted were conifers that were used to establish plantations (the vast majority of the arborvitae was planted as part of the shoreline hedge). The planting of nearly 650,000 sugar maples (all of which were natural seedlings "pulled" from the wilds of western Massachusetts) has resulted in an unusually high component of this species. In addition, red oak, American chestnut, ash, tamarack, hemlock and other species were planted. In 1906, 22,845 Douglas-fir seedlings were set out. Few are alive today although one is officially recognized as the largest in Massachusetts. Even giant sequoias (Sequoiadendron giganteum) were grown in the nursery for seven years until they died during the winter of 1918 with none ever planted out. Along with the seedlings, bushels of acorns and hickory nuts were heeled-in.

The records are, unfortunately, rather sparse regarding forest management during the first half of the 20th Century. The earliest annual reports refer to "improvement" operations typically described as, "The work of cutting out fruit and dead and undesirable trees." It is unknown if a professional forester was involved. The 1907 annual report mentions that all forestry related activities have been reclassified from construction to maintenance. In Fernow's 1903, Economics of Forestry, an improvement thinning is discussed as follows:

> The forester, instead of culling out the best kinds first, as the lumberman does, would take out undesirable ones first, and thus improve the composition of his crop. The material that results from these so-called "improvement cuttings" may sometimes not directly pay for the labor spent on them, but they are cultural operations, designed to put the property in more useful condition for the future, and hence they are at least indirectly profitable.

The term "improvement" seems to have been used rather loosely in the Annual Reports suggesting that a forester was not involved or at least not involved in writing the forestry section of the annual reports. In addition to describing proper improvement thinnings, "improvement" was most commonly used to describe work in preparing an already forested site for planting. It was also used when describing the cutting of young hardwoods or brush that interfered with the newly planted pines and the cutting of all understory vegetation within 100 feet of the highways (the "100 foot margins"). Regardless, a great deal of attention was paid to the forest around the Wachusett Reservoir for the first forty years of the last century and all of it with the intention of creating as ideal a forest cover for the production of high quality water as possible.

Unfortunately, there followed a period from about 1940 through the 1970's when little attention was paid the forest other than salvage work and planting immediately following the hurricane of 1938. This is precisely when the 1,045 acres of plantations that were established at a six-by-six foot spacing should have been receiving their initial thinning. Instead, what faced the first foresters in 1979 (the year of the first professionally administered timber harvest) were plantations then 40 to 70 years old that were severally overstocked, comprised of trees with short constricted crowns and sparse understories. Stands of this nature are highly susceptible to windthrow and disease and therefore were rather poor protectors of the water resource. The result could have been what one can see at the North Dike plantation, which was unique in having been first thinned in 1959 by the first Quabbin forester, Fred Hunt, and subsequently treated several times. The trees are well spaced, windfirm with deep crowns and excellent regeneration beneath.

From fiscal year 1980 through 2000, 3,306 acres of MDC forest at Wachusett have received silvicultural treatment (Table 9).

TABLE 9. FORESTED ACRES TREATED BY FISCAL YEAR

Year	Acres Treated	Year	Acres Treated
1979	292	1991	76
1980	124	1992	138
1981	146	1993	65
1982	279	1994	152
1983	222	1995	224
1984	251	1996	84
1985	141	1997	237
1986	67	1998	300
1987	41	1999	252
1989	82	2000	58
1990	75	**Total**	**3,306**

An additional 442 acres have received salvage treatment, the majority following Hurricane Gloria in 1985 and 1986 and a severe thunderstorm in 1989.

TABLE 10. ACRES SALVAGED BY YEAR

Year	1983	1985	1986	1989	1990	1992	2000	TOTAL
Acres	7	94	47	285	5	2	2	442

TABLE 11. ACRES TREATED BY SUB-BASIN

Sub-basin	Name	Acres
1	Res. Shoreline North (Gates 36 - Rt. 12)	547
2	Res. Shoreline South (Rt. 12 - Malag. Bk.)	207
3	Res. Shoreline East (Malag. Bk. - Gate 40)	615
4	Thomas, Quinapoxet and Stillwater Basins	271
5	French Brook	34
7	Malagasco Brook	13
8	Muddy Brook	4
9	Gates Brook	140
11	Malden Brook	45
12	Chaffins Brook	35
13	Asnebumskit Brook	2
14	Quinapoxet River	551
15	Trout Brook	73
16	Waushacum Brook	219
17	South Stillwater River	66
18	Middle Stillwater/Rocky Bk./Wilder Bk.	75
19	North Stillwater/ Justice Brook	27
20	Wachusett Brook	47
21	Off-Watershed Lands	335

2.3.2 Forest Types, Ages, and Conditions

2.3.2.1 Forest Types

The Wachusett forest is comprised of hundreds of individual stands. Each is defined as "a contiguous group of trees sufficiently uniform in species composition, arrangement of age-classes, and condition to be a distinguishable unit." Many of the differences between stands can be attributed to past land-use histories and stand origination. An easy prediction is that the stand type will change on the other side of the stone wall. These often abrupt stand boundaries will tend to blur as management and time allow the underlying ecological pattern to emerge.

Forest cover type maps have been created and updated by MDC foresters since the early 1980's. Table 12 shows the acres in these various forest types. Currently, these maps are made and updated by hand. However, within the next year, all of these maps will be converted to a digital format allowing for analysis using GIS technology.

TABLE 12. ACREAGE OF MDC-OWNED FOREST AT WACHUSETT BY TYPE

Forest Type	Acres	Percent
Mixed Oak	1909	16.9
White Pine-Oak	1725	15.3
Mixed Hardwoods	1516	13.4
White Pine-Hardwoods	1507	13.3
Red Maple	1147	10.1
White Pine	997	8.8
Oak-Hardwoods	992	8.8
Red Oak	947	8.4
Red Pine	146	1.3
Mixed Pine-Hardwoods	143	1.3
Northern Hardwoods	124	1.1
Hemlock-Hardwoods	122	1.1
Spruce	32	0.3
Total	***11,307***	***100***

2.3.2.2 Species Distribution

Species distribution is based on forest inventory completed by MDC foresters in 1998. Although over 40 species of trees were identified, five species account for 82% of the trees per acre and basal area per acre. These top five species are (listed in order by basal area): white pine, red maple, red oak, black oak and white oak. Other common species include white ash, red pine, hickory, black birch and eastern hemlock.

2.3.2.3 Size Distribution

The following charts illustrate the structural diversity of the Wachusett forest. However, none of these give a true indication of the age structure of the forest. Tree diameter is poorly correlated to age. Forest type map analysis gives some clue; trees of less than 40 feet in height occupy approximately 7.4%

of the forested acreage. The vast majority of these stands is the direct result of forest management operations, storm damage and field succession during the last 20-30 years. Taking into account the additional acres of small-scale unmapped young age-class areas throughout the forest, it can be conservatively estimated that not more than 10% of the forested acreage is in these young age-classes.

CHART 1. BASAL AREA BY SPECIES ON MDC LANDS ON WACHUSETT RESERVOIR WATERSHED

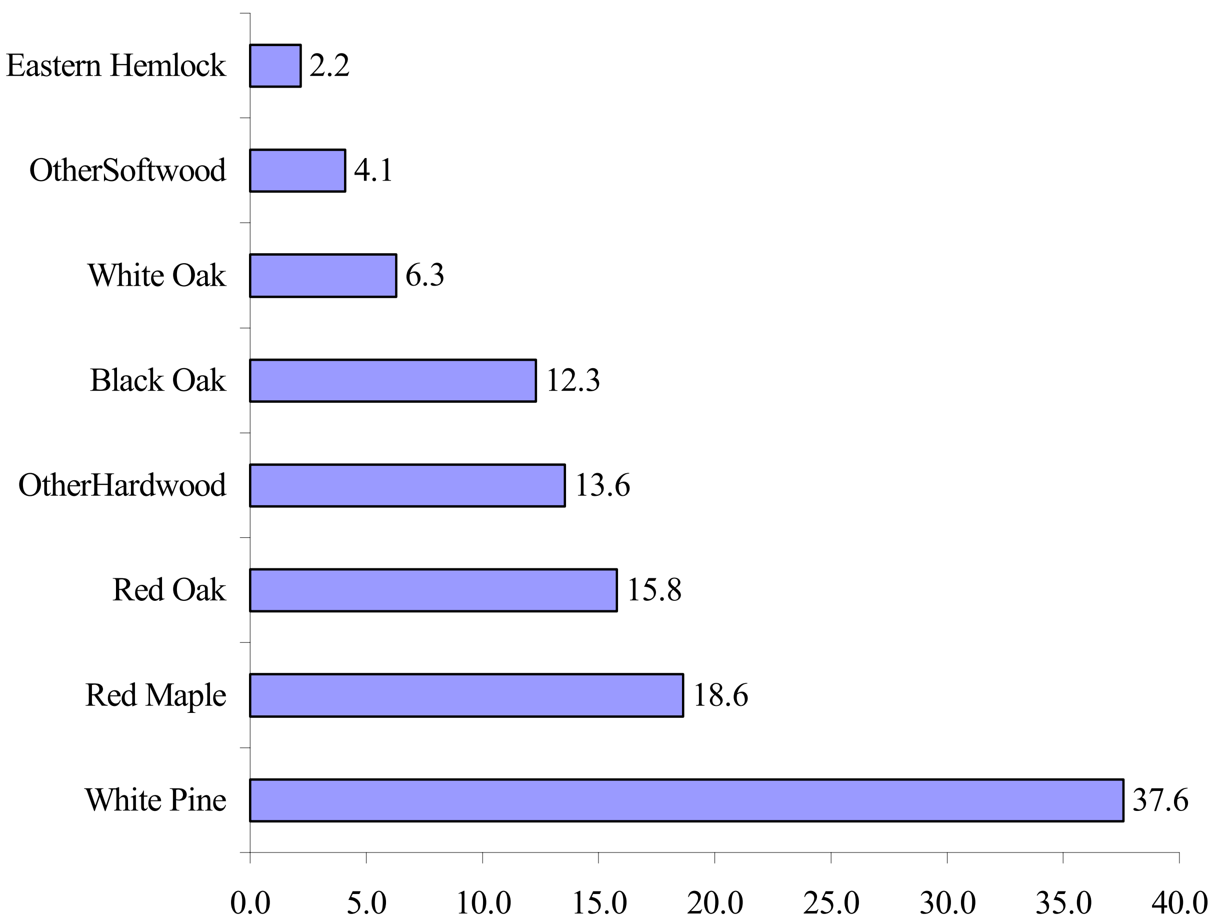


CHART 2. TREES/ACRE BY SPECIES, MDC LANDS ON WACHUSETT RESERVOIR WATERSHED

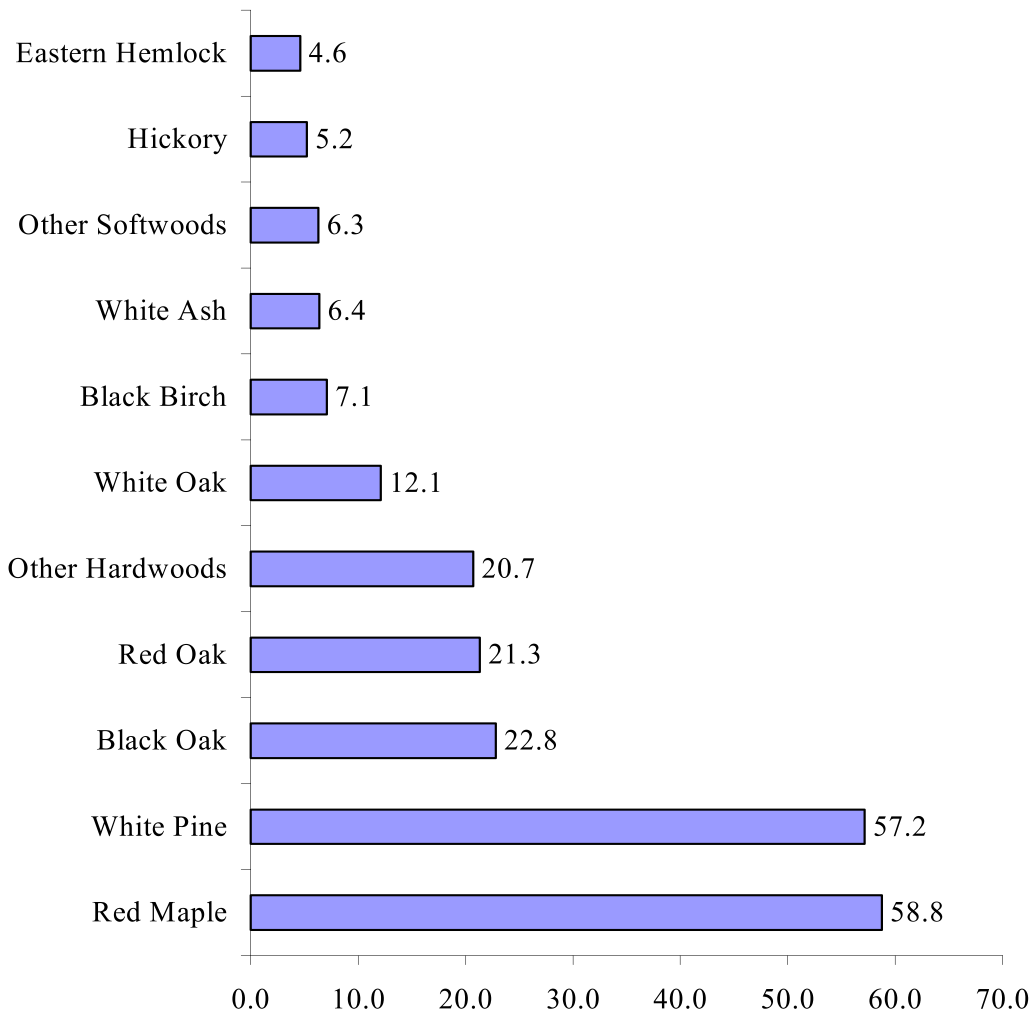
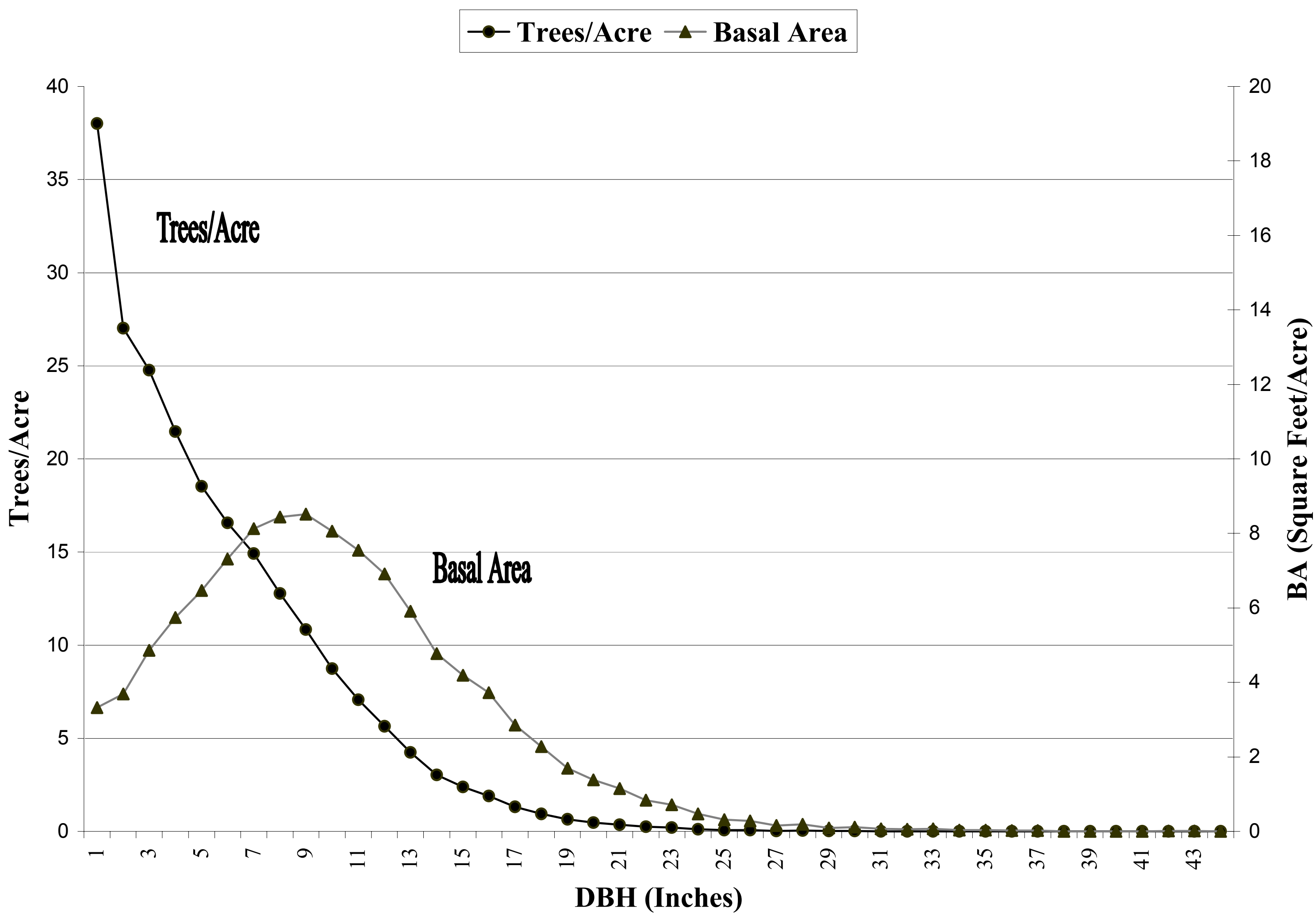


CHART 3. BASAL AREA AND TREES/ACRE BY DBH,

MDC LANDS ON WACHUSETT RESERVOIR WATERSHED



2.3.3 Wachusett Flora, Common and Uncommon

T. Kyker-Snowman

Polygala paucifolia,
Fringed polygala

During 1995 and 1996, MDC contracted with the University of Massachusetts Herbarium to inventory proposed harvesting areas for the presence of rare plant species. During this inventory, the Herbarium also compiled a flora, a list of all species encountered. The list of species encountered at Wachusett is included below:

TABLE 13. PLANT SPECIES OCCURRING ON CHECKED LOTS AT WACHUSETT

Field List – Flora
1996 Survey of Proposed Harvesting Lots
Karen Searcy - U Mass Herbarium
rare species underlined and bold;
*invasive species

Dicots

Acer pensylvanicum	Striped maple
Acer rubrum	Red maple
Acer saccharinum	Silver maple
Acer saccharum	Sugar maple
Actaea pachypoda	Doll's eyes
Actaea sp.	Baneberry
Amelanchier sp.	Shadbush
Amphicarpaea bracteata	Hog peanut
Anemone quinquefolia	Wood anemone
Apios americana	Groundnut
Apocynum androsaemifolium	Spreading dogbane
Apocynum sp.	Dogbane
Aralia nudicaulis	Wild sarsaparilla
Aronia arbutifolia	Cherry
Aronia melanocarpa	Choke cherry
Aster acuminatus	Whorled aster
Aster divaricatus	White wood aster
Aster linariifolius	Stiff leaf aster
Baptisia tinctorea	False indigo
**Berberis sp.*	Barberry
**Berberis thunbergii*	Japanese barberry
Betula alleghaniensis	Yellow birch
Betula lenta	Black birch
Betula papyrifera	White birch
Betula populifolia	Gray birch
Boehmeria cylindrica	False nettle
Carpinus caroliniana	Iron wood
Carya ovata	Shagbark hickory
Carya sp.	Hickory
Castanea dentata	Chestnut
Ceanothus americanus	New Jersey tea
**Celastrus orbiculatus*	Japanese bittersweet
Celastrus sp.	Bittersweet
Chelidonium majus	Celandine
Chimaphila maculata	Spotted wintergreen
Circaea lutetiana var. canadensis	Canadian en. night.
Comandra umbellata	Umbellate toadflax
Comptonia peregrina	Sweet fern
Coptis trifolia	Goldthread
Cornus alternifolia	Alternate-leaf dogwood
Cornus canadensis	Bunch berry
Cornus florida	Flowering dogwood
Cornus sp.	Dogwood
Corylus americana	American hazelnut
Corylus cornuta	Beaked hazelnut
Crataegus sp.	Hawthorn
Diervilla lonicera	Bush honeysuckle
Epigaea repens	Trailing arbutus
Euonymus alatus	Winged spindle-tree
Fagus grandifolia	Beech
Fraxinus americana	White ash
Fraxinus pennsylvanica	Green ash
Fraxinus sp.	Ash
Galium sp.	Bedstraw
Gaultheria procumbens	Wintergreen
Gaylussacia baccata	Black huckleberry
Gaylussacia sp.	Huckleberry
Geranium maculatum	Wild geranium
Hamamelis virginiana	Witch hazel
Helianthemum sp.	Rockrose
Hieracium pratense	King devil (hawkweed)
Ilex verticillata	Winterberry
Impatiens capensis	Jewelweed
Kalmia angustifolia	Sheep laurel
Kalmia latifolia	Mountain laurel
Lespedeza sp.	Bush-clover
Ligustrum vulgare	Privet
**Lonicera sp.*	Honeysuckle

Lyonia ligustrina	Maleberry
Lysimachia quadrifolia	Whorled loosestrife
Lysimachia terrestris	Swamp candles
Melampyrum lineare	Cow wheat
Mitchella repens	Partridge berry
Monotropa uniflora	Indian-pipe
Myrica gale	Sweet gale, meadow-fern
Nyssa sylvatica	Black gum
Ostrya virginiana	American hop-hornbeam
Oxalis sp.	Wood sorrel
Parthenocissus quinquefolia	Virginia creeper
Parthenocissus sp.	Virginia creeper
Polygala paucifolia	Fringed polygala
Populus tremuloides	Quaking aspen
Potentilla canadensis	Canadian cinquefoil
Potentilla simplex	Old-field cinquefoil
Prenanthes trifoliolata	Gall-of-the-earth
Prunus serotina	Black cherry
Prunus sp.	Cherry
Pyrola elliptica	Shinleaf
Pyrola rotundifolia	Round-leafed pyrola
Quercus alba	White oak
Quercus coccinea	Scarlet oak
Quercus rubra	Red oak
Quercus velutina	Black oak
Ranunculus acris	Common buttercup
Rhamnus frangula	Alder-buckthorn
**Rhamnus sp.*	Buckthorn
Toxicodendron radicans	Poison ivy
Ribes cynosbati	Prickly gooseberry
Ribes sp.	Currant
Robinia pseudo-acacia	Black locust,false acacia
Rosa sp.	Rose
Rubus allegheniensis	Black raspberry
Rubus flagellaris	Dewberry
Rubus hispidus	Swamp dewberry
Rubus sp.	Blackberry
Sassafras albidum	Sassafras
Sedum purpureum	Garden orpine
Solanum dulcamara	Nightshade
Solidago sp.	Goldenrod
Spiraea alba var. latifolia	Meadowsweet
Taraxacum officinale	Common dandelion
Taraxacum sp.	Dandelion
Thalictrum sp.	Meadow rue
Tilia americana	Basswood
Trientalis borealis	Starflower
Ulmus americana	American elm
Ulmus rubra	Slippery elm
Ulmus sp.	Elm
Vaccinium angustifolium	Low-bush blueberry
Vaccinium corymbosum	High-bush blueberry
Vaccinium pallens	Early sweet blueberry
Veronica officinalis	Common speedwell
Viburnum acerifolium	Maple-leafed viburnum
Viburnum cassinoides	Witherod
Viburnum dentatum var. lucidum	Southern arrow wood
Viola sp.	Violet
Vitis sp.	Grape

Monocots

Agrostis sp.	Bentgrass
Andropogon scoparius	Bluestem
Arisaema sp.	Jack-in-the-pulpit
Arisaema triphyllum	Small jack-in-the-pulpit
Brachyelytrum erectum	Awned woodgrass
Carex debilis	Weak sedge
Carex pen/communis	Colonial sedge
Carex pensylvanica	Penn. Sedge
Carex platyphylla?	Broad-leaved sedge
Carex sp.	Sedge
Carex (stellulatae group)	
Carex stricta	Erect sedge
Carex swanii	Swan sedge
Carex sylvatica	Sedge-of-the-woods
Carex vulpinoidea	Foxtail-flowered sedge
Clintonia borealis	Yellow clintonia
Cypripedium acaule	Pink lady's slipper
Danthonia spicata	Junegrass
Epipactis helleborine	Helleborine
Glyceria sp.	Manna-grass
Glyceria striata	Fowl-meadow grass
Goodyera pubescens	Rattlesnake plantain
Goodyera sp.	Plantain
Iris versicolor	Blue flag
Isotria verticillata	Large whorled pogonia
Juncus tenuis	Slender rush
Maianthemum canadense	Canada mayflower
Medeola virginiana	Indian cucumber root
Orchid sp.	Orchid
Oryzopsis sp.	Rice grass
Panicum sp.	Panic grass
Poa sp.	Grass
Polygonatum pubescens	Hairy Solomon's seal
Polygonatum sp.	Solomon's seal
Saggitaria sp.	Arrowhead
Smilacina racemosa	False solomon's seal

Smilax herbacea	Jacob's ladder
Smilax rotundifolia	Common greenbrier
Smilax sp.	Greenbrier
Symplocarpus foetidus	Skunk cabbage
Trillium sp.	Trillium
Uvularia sessilifolia	Wild oats

Fern Allies

Equisetum sp.	Horsetail
Diphasiastrum digitatum	Trailing evergreen
Diphasiastrum tristachyum	Ground pine
Lycopodium clavatum	Common clubmoss
Lycopodium hickeyi	Hickey's clubmoss
Lycopodium obscurum	Tree clubmoss

Ferns

Athyrium filix-femina	Lady fern
Athyrium thelypteroides	Silvery spleen
Dennstaedtia punctilobula	Hay-scented fern
Dryopteris cristata	Crested wood fern
Dryopteris intermedia	Spinulose wood fern
Dryopteris marginalis	Marginal shield fern
Dryopteris spinulosa	Spinulose wood fern
Onoclea sensibilis	Sensitive fern
Osmunda cinnamomea	Cinnamon fern
Osmunda claytoniana	Interrupted fern
Osmunda regalis	Royal fern
Polypodium virginianum	Rock polypody
Polystichum acrostichoides	Christmas fern
Pteridium aquilinium	Bracken fern
Thelypteris noveboracensis	New York fern

Gymnosperms

Juniperus communis	Common juniper
Picea abies	Norway spruce
Picea sp.	Spruce
Pinus resinosa	Red pine
Pinus strobus	White pine
Pinus sylvestris	Scotch pine
Taxus canadensis	American yew
Thuja occidentalis	Arbor vitae
Tsuga canadensis	Hemlock

This list is not meant to be comprehensive for the entire watershed, but serves as a starting point for assessing the diversity of species present at Wachusett. In addition to the rare or uncommon species highlighted above (bold, underlined), there are uncommon species that have some likelihood of being found at Wachusett, were a comprehensive search initiated. These are listed in the table below, and are based on historic records from the herbarium and other sources.

TABLE 14. UNCOMMON PLANTS POTENTIALLY OCCURRING ON MDC PROPERTIES

Family	Species	Common Name	Status	Flowering
Apiaceae	*Conioselium chinense*	Hemlock Parsley	SC	Jul/Sep
Apiaceae	*Sanicula trifoliata*	Trefoil Sanicle	WL	Jun/Oct
Asclepiadaceae	*Asclepias verticillata*	Linear-leaved Milkweed	T	May/Jul
Asteraceae	*Aster radula*	Rough aster	WL	Jun/Aug
Brassicaceae	*Arabis drummondii*	Drummond's Rock-cress	WL	May/Aug
Brassicaceae	*Arabis missouriensis*	Green rock-cress	T	Jul/Oct
Brassicaceae	*Cardamine bulbosa*	Spring Cress	WL	Jun/Aug
Caryophyllaceae	*Stellaria borealis*	Northern Stitchwort	WL	May/Aug
Cyperaceae	*Eleocharis intermedia*	Intermediate spikerush	T	Aug/Oct
Cyperaceae	*Scirpus ancistrochaetus*	Barbed-bristle bulrush	E	Jun/Jul
Fabaceae	*Lupinus perennis*	Wild Lupine	WL	May/Jul
Gentianaceae	*Gentiana andrewsii*	Andrew's Bottle Gentian	T	Apr/Jun
Gentianaceae	*Gentiana linearis*	Narrow-leaved Gentian	WL	Jun/Aug
Haloragaceae	*Myriophyllum alterniflorum*	Alternate leaved Milfoil	T	Jun/Aug
Juncaceae	*Juncus filiformis*	Thread rush	T	Aug
Lentibulariaceae	*Utricularia minor*	Lesser bladderwort	WL	May/Nov
Liliaceae	*Smilacina trifolia*	Three-leaved Solomon	WL	Apr/Jun
Loranthaceae	*Arceuthobium pusillum*	Dwarf mistletoe	SC	May/Sep
Orchidaceae	*Coeloglossum viride v. bracteata*	Frog orchid	WL	May/Sep
Orchidaceae	*Corallorhiza odontorhiza*	Autumn coralroot	SC	Apr/Jul

Family	Species	Common Name	Status	Flowering
Orchidaceae	*Cypripedium calceolus v. parviflorum*	Small Yellow Lady Slipper	E	May/Aug
Orchidaceae	*Cypripedium calceolus v. pubescens*	Large Yellow Lady Slipper	WL	Jun/Sep
Orchidaceae	*Isotria medeoloides*	Small whorled pogonia	E	May/Jul
Orchidaceae	*Platanthera hookeri*	Hooker's Orchid	WL	Mar/Jun
Orchidaceae	*Platanthera macrophylla*	Large leaved Orchis	WL	Apr/Jul
Orchidaceae	*Platanthera. flava var. herbiola*	Pale Green Orchis	T	Jun/Sep
Orchidaceae	*Triphora trianthophora*	Nodding Pogonia	E	Jul/Sep
Poaceae	*Panicum philadelphicum*	Philadelphia Panic Grass	SC	Jul
Poaceae	*Trisetum pensylvanica*	Swamp Oats	T	Aug/Oct
Poaceae	*Trisetum spicatum*	Spiked False Oats	E	Jul/Sep
Ranunculaceae	*Ranunculus alleghaniensis*	Allegheny buttercup	WL	Jun/Sep
Sparganiaceae	*Sparganium angustifolium*	Narrow-leaved Bur Weed	WL	May/Nov
Urticaceae	*Parietaria pensylvanica*	Pellitory	WL	Aug/Sep

NOTE: For Status, E = endangered, T = threatened, SC = special concern, WL = watch list

MDC Foresters have located the following state-listed species during independent surveys of Wachusett properties:

Lupinus perennis	Wild lupine	WL
Isotria verticillata	Large whorled pogonia	WL
Arceuthobium pusillum	Eastern dwarf mistletoe	SC
Juglans cinerea	Butternut	WL
Orontium aquaticum	Golden club	T

Based on *The Vascular Plants of Massachusetts: A County Checklist*, 1999, by B. A. Sorrie and P. Somers, the following table summarizes species on state lists that have been found in Worcester County.

TABLE 15. NUMBERS OF WORCESTER COUNTY SPECIES ON STATE LISTS

	Endangered	Threatened	Special Concern	Watch List	Historical
Native	24	20	11	62	9
Introduced	3	1	0	4	1
Uncertain	1	1	2	3	0

Working with the U Mass herbarium, MDC has identified the following habitat/rare species relationships:

TABLE 16. HABITATS IN WHICH RARE SPECIES ARE LIKELY TO BE FOUND

***Forested Areas**:*

<u>Rich Mesic Woods</u> (less acid - rich herbaceous layer. Indicators: *Acer saccharum*, *Fraxinus americana*, *Adiantum pedatum*, *Asarum canadense*)

Species	Common name	Comments
Acer nigrum	Black Maple	
Cerastium nutans	Nodding Chickweed	
Coeloglossum viride v. bracteata	Frog orchid	to dry rocky woods
Corallorhiza odontorhiza	Autumn coralroot	to dry/seasonally wet streamlets
Cypripedium calceolus v. pubescens	Large Yellow Lady Slipper	slopes and talus
Equisetum pratense	Horsetail	sandy places
Panax quinquefolius	Ginseng	talus and base of ledge areas
Platanthera hookeri	Hooker's Orchid	often rocky or swampy
Ranunculus alleghaniensis	Allegheny buttercup	rocky
Ribes lacustre	Bristly Black Current	
Sanicula canadensis	Canadian Sanicle	
Sanicula gregaria	Long-Styled Sanicle	
Sanicula trifoliata	Trefoil Sanicle	

<u>Moist Coniferous / Pine Woods</u>

Species	Common Name	Comments
Goodyera repens	Dwarf Rattlesnake Plantain	pine woods
Moneses uniflora	One-Flowered Pyrola	moist rich woods

<u>Hemlock-Northern Hardwoods</u>

Species	Common Name	Comments
Isotria medeoloides	Small whorled pogonia	vernally moist areas
Platanthera macrophylla	Large leaved Orchis	moist ravines, limey
Rhododendron maximum	Rhododendron	hemlock island in swamp
Triphora trianthophora	Nodding Pogonia	depressions under beech
Viola renifolia	Kidney Leaved Violet	damp rich woods

General Habitat:

<u>Boulder/Talus Slope/Ledges</u>

Species	Common name	Comments
Adlumia fungosa	Climbing Fumitory	Shaded limey talus
Amelanchier sanguinea	Roundleaf Shadbush	Ledges & ridge tops
Arabis drummondii	Drummond's Rock-cress	
Arabis missouriensis	Green rock-cress	open rock and scree
Chenopodium gigantospermum	Maple-leaf Goosefoot	shaded dry ledges
Clematis occidentalis	Purple Clematis	exposed ledges & talus
Parietaria pensylvanica	Pellitory	shaded shelves
Pinus resinosa	Red Pine	exposed, rocky ridge tops
Rosa blanda	Smooth rose	dry to mesic rocky slopes
Trisetum spicatum	Spiked False Oats	Exposed

Sandplain / Open Meadow

Species	Common name	Comments
Asclepias verticillata	Linear-leaved Milkweed	open rocky
Eragrostis capillaris	Lace Love Grass	open sandy soil
Gentiana andrewsii	Andrew's Bottle Gentian	open/meadow
Liatris scariosa var novae-angliae	New England Blazing Star	sandy open pine wds.
Lupinus perennis	Wild Lupine	sandy open pine wds.
Paspalum setaceum	Paspalum	sandy soil
Penstemon hirsutus	Beard-Tongue	dry or rocky ground
Polygala verticillata	Whorled Milkwort	open woods/old field/stony shores

Aquatic Habitats:

Ponds / Streams

Species	Common name	Comments
Aster tradescantii	Tradescant's Aster	Fields/swamps
Betula nigra	River Birch	Swamps & stream banks
Cardamine longii	Long's Bitter-cress	Swampy streams
Eleocharis intermedia	Intermediate spikerush	Exposed shores
Juncus filiformis	Thread rush	Meadows/springs/riverbank
Megalodonta beckii	Water marigold	
Myriophyllum alterniflorum	Alternate leaved Milfoil	
Nuphar pumila	Tiny Cow-Lily	
Panicum philadelphicum	Philadelphia Panic Grass	Exposed shores
Scirpus ancistrochaetus	Barbed-bristle bulrush	Swales and shores
Sparganium angustifolium	Narrow-leaved Bur Weed	
Sparganium fluctuans	Bur-Reed	
Utricularia minor	Lesser bladderwort	Seepy stream sides
Utricularia resupinata	Bladderwort	Swamps, swales, shores

Seeps / Seepage Areas

Species	Common name	Comments
Cardamine bulbosa	Spring Cress	
Conioselium chinense	Hemlock Parsley	Black ash seepage swamps
Cypripedium calceolus v. parviflorum	Small Yellow Lady Slipper	Black ash seepage swamps
Elatine americana	American Waterwort	Wet clay soil
Mimulus moschatus	Muskflower	Open seepage area
Pedicularis lanceolata	Lousewort	Open areas
Platanthera flava var. herbiola	Pale Green Orchis	Vernal streams in hardwoods
Stellaria borealis	Northern Stitchwort	
Trisetum pensylvanica	Swamp Oats	

Bogs / Boggy Areas

Species	Common name	Comments
Arceuthobium pusillum	Dwarf mistletoe	On Black Spruce
Arethusa bulbosa	Arethusa	
Aster radula	Rough aster	beaver meadows/swamp borders
Gentiana linearis	Narrow-leaved Gentian	boggy meadows
Scheuchzeria palustris	Pod Grass	
Smilacina trifolia	Three-leaved Solomon	boggy woods

Species	**Common name**	**Comments**
Viola nephrophylla	Northern Bog Violet	
Xyris montana	Northern Yellow-eyed grass	

2.3.4 Wildlife

2.3.4.1 Overview of Wildlife Community

The type and extent of available habitats drive the wildlife community in any particular area. Specific wildlife species each have unique habitat requirements. The Wachusett Watershed is a mosaic of habitat types and conditions. MDC owned land within the watershed is primarily forested, while privately owned lands are comprised of small farms, woodlots, and residential areas. This patchwork of habitats is both a benefit and detriment to wildlife species. A greater diversity of species may exist because of the diversity of habitats. However, the fragmented nature of the watershed makes it more difficult for animal species to travel and interact, and in some cases, the different habitat areas may be too small to support individual animals or populations.

T. Kyker-Snowman

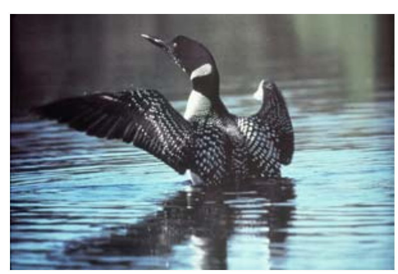
Wild turkey hen

Overall, Wachusett supports a variety and abundance of wildlife species. Wachusett Reservoir supports many water-based species (common loons, spotted sandpipers, bald eagles), and the many streams, lakes, and beaver ponds within the watershed host a variety of birds, amphibians, and reptiles. MDC forests provide habitat for a diversity of birds and mammals including white-tailed deer, turkey, grouse, raccoons, and fisher. In addition, neotropical songbirds, including black and white warblers, black-throated green warblers, and scarlet tanagers utilize MDC forests for breeding and migratory rest stops. Although a majority of MDC owned land in the Wachusett watershed is forested, several large tracts of early successional habitat do exist. These large open, grassy areas provide critical habitat for a variety of species dependent on open lands, including various insects, eastern meadowlarks, bobolinks, and a variety of sparrows.

Probably the most important feature of MDC owned land in the Wachusett watershed is that it is protected from development. As the Boston metropolis expands westward, there remain fewer and fewer acres of open space. The protection MDC lands provide to wildlife species is critical to their long-term survival.

In the last few years, the Division has conducted a variety of surveys to monitor various species of wildlife in the watershed. A yearly bald eagle survey is done each winter. In addition, annual surveys of common loons, Canada geese, and beaver are done at the Reservoir. Other state agencies occasionally conduct wildlife surveys on the watershed, including sampling for fish, waterfowl, and some mammals. In addition, recent surveys to document and sample vernal pools have been conducted. Some of these pools are monitored on a yearly basis.

While a great deal of information exists about certain wildlife taxa (i.e. birds, mammals) through information collected from surveys and observations, very little is known about other Wachusett wildlife. A complete species list for the watershed does not exist, and there is a paucity of information about insects, butterflies, dragonflies, and other more secretive species. It is possible that MDC lands in the Wachusett harbor state listed species that have yet to be documented.



P. Rezendes

Common loon

2.3.4.2 Rare Species and Habitats

Wachusett watershed harbors a variety of rare wildlife species and habitats. A total of 11 vertebrate state listed wildlife species are known to occur on the watershed, and most of those occurrences have been on MDC land. Table 17 indicates those species with their last known observation date.

Although a majority of MDC owned land in Wachusett watershed is forested, there are several unique areas that support rare or unusual habitat. Poutwater Pond (Holden) is one of the best examples in the state of an acidic fen. A floating bog mat provides very rare habitat for a number of uncommon species. The Division owns a large number of vernal pools. Although not rare on MDC owned land, these unique breeding areas are becoming increasingly rare on a regional level.

TABLE 17. STATE-LISTED ANIMALS KNOWN TO OCCUR IN THE WACHUSETT WATERSHED

Common Name	Scientific Name	Status		Date Last Observed
Mammals:		State	Federal	
Water Shrew	*Sorex palustris*	SC[1]		1990
Birds:				
Common Loon	*Gavia immer*	SC		2001
Bald Eagle	*Haliaeetus leucocephalus*	E[2]	T[3]	2001
Short-eared Owl	*Asio flammeus*	E		1998
American Bittern	*Botaurus lentiginosus*	E		1992
Northern Harrier	*Circus cyaneus*	T		1997
Reptiles/Amphibians:				
Spring Salamander	*Gyrinophilus porphyriticus*	SC		1993
Wood Turtle	*Clemmys insculpta*	SC		1999
Blanding's Turtle	*Emydoidea blandingii*	T		1999
Spotted Turtle	*Clemmys guttata*	SC		1999
Four-Toed Salamander	*Hemidactylium scutatum*	SC		1990
Marbled Salamander	*Ambystoma opacum*	T		2000

[1] Special Concern: species documented to have suffered a decline that could threaten the species if allowed to continue unchecked.
[2] Endangered: species in danger of extinction throughout all or a significant portion of its range.
[3] Threatened: species likely to become endangered within the foreseeable future throughout all or a significant portion of its range.

2.4 Cultural Resources at Wachusett

2.4.1 Prehistoric Overview

The Nashua River Basin is one of a number of significant tributary systems of the Merrimack River Basin. Prior to damming the Upper reaches of the South Branch of the Nashua River in 1908 to form the Wachusett Reservoir, the region's numerous lakes, ponds, wetlands, and streams supported abundant and readily available biotic resources.

The Wachusett Watershed is located near the eastern edge of the Worcester Plateau, which delineates the Central Uplands to the west from the Coastal Plain to the east. The terrain and topography of the region is very diverse as it was influenced by a combination of the bedrock formations and by later glaciation.

The composition of the bedrock, together with glacial and postglacial deposition and erosion, has created a mosaic of landforms, sediments and soils. This complexity, combined with a diverse flora and fauna base, have contributed to the many forms of land use practiced throughout the 12,000 years that humans have occupied the region.

Currently there are a total of twenty-seven recorded prehistoric Native American sites within, or in close proximity to, the Wachusett Watershed (Table 18). Within the greater Nashua River Basin, of which Wachusett is a part, at least another thirty-five sites have been recorded. This quantity is known to be low as it represents only those recorded at the Massachusetts Historical Commission, and does not take into account the many more that are known to collectors but are not recorded. Combined, the recorded and unrecorded sites clearly attest to the viability of this region's habitat for human habitation for thousands of years, and establishes the archaeological sensitivity of the region.

The existing archaeological evidence, flawed as it is, suggests that ***Paleo Indian*** hunters and gatherers may have reached the Nashua River Basin by 9,500 to 12,000 years ago. An unconfirmed find of an Eastern Fluted Point, the diagnostic artifact of the Paleo Period, from south Lancaster, adjacent to South Meadow Pond, is the only hint of human activity in the Nashua Basin itself. However, within the broader context of the Merrimack River Basin, of which the Nashua is a tributary, isolated fluted points have been recovered in Andover and Boxford, on the lower Merrimack, as well as on the middle reaches of the river in New Hampshire. The confluence of the Concord, Assabet and Sudbury rivers may also have been occupied at this time.

By about 9,500 years ago the warming climate had created an environment in southern New England that supported a mixed pine-hardwood forest. Although there are no recorded ***Early Archaic*** sites (ca. 9,500 to 8,000 years ago) in the Nashua River Basin, three sites have yielded the diagnostic Early Archaic Bifurcate Based Point within the lower Merrimack Valley. Low frequencies of Early Archaic materials have also been reported from two sites in New Hampshire. Analysis of private artifact collections also suggests the presence Early Archaic activity on the lower Assabet River ca. 9,500 - 8,000 years ago.

During the ***Middle Archaic period*** (ca. 8,000 - 6,000 years ago) climatic and biotic changes continued, and the mixed deciduous forests of southern New England were becoming established. Significantly, it is believed that the present migratory patterns of many fish and birds became established at this time. During the spring those rivers, streams and ponds utilized by anadromous fish for spawning would have been particularly important for fishing. Groups are likely to have traveled considerable distances to camp adjacent to falls and rapids where they could easily trap and spear the salmon, herring, shad, and alewives. This subsistence strategy persisted throughout prehistory.

Two sites known to be on MDC land were occupied during this time. The Muddy Brook Site, located at South Bay in West Boylston, has yielded at least one Middle Archaic artifact to an astute fisherman. When it was occupied the site was a short distance from the brook's confluence with the Nashua River. The second site is a large multi-component site between East and West Waushacum ponds (see below).

More sites in the Nashua Basin have yielded diagnostic ***Late Archaic period*** materials than the preceding periods. The marked increase in site frequencies and densities is consistent with findings throughout most of southern New England, and may document a population increase ca. 6,000 to 3,000 years ago. At least six sites within the watershed appear to have been occupied during the Late Archaic Period: two sites on Waushacum Pond, two on Eagle Pond, one on Chaffin Pond, and the South Bay Quartzite Quarry.

During the ***Early, Middle*** and ***Late Woodland*** periods (3,000 - 450 before present (B.P.)) Native Americans continued to occupy the Nashua River Basin. Evidence comes from five sites from each period. Regionally, horticulture was introduced during the Early Woodland and small gardens may have been planted in clearings located on the fertile alluvial terraces next to the Nashua River and its larger tributaries.

Because of the manner in which sites were discovered or collected it is impossible to distinguish with certainty the nature of Native American occupation here during the various Woodland Periods. Five sites hint at Early Woodland activities based on the presence of Small Stemmed Points, which are also used to identify Late Archaic affiliations. Two may have been Late Woodland sites. Currently, it is difficult to conclusively identify Middle Woodland sites from the existing artifact descriptions. One can only speculate that Native American presence continued here between 1,200 to 900 years ago, and that the area was not abandoned for some unknown reason.

TABLE 18. PREHISTORIC SITE INVENTORY

Town	Site	Type
Boylston	19-WR-220 Indian Rock	Unknown
Holden	19-WR-21 Quinapoxet Pond	Unknown
	19-WR-29 Eagle Lake (E)	Late Archaic/Early Woodland unknown
	19-WR-30 Eagle Lake (SE)	Late Archaic/Late Woodland
	19-WR-31 Eagle Lake (SW)	Unknown
	19-WR-33 Maple Spring Pond (E)	Unknown
	19-WR-34 Maple Spring Pond (W)	Unknown
	19-WR-181 Chaffin Pond	Unknown
	19-WR-182 Chaffin Pond	Late Archaic/Late Woodland
	19-WR-183 Chaffin Pond	
	19-WR-184 Rockshelter	Unknown
	19-WR-253 Quabbin Aqueduct	
Lancaster	19-WR-259 South Meadow Pond	Paleo
Sterling	19-WR-12 East Waushacum Pond	Unknown
	19-WR-13 Wattaquadock	Historic NA burial
	19-WR-14 unnamed	Historic NA burial
	19-WR-15 West Waushacum Pond	Historic NA burial
	19-WR-16 Selma-Wheaton	Middle & Late Archaic/Early Woodland
	19-WR-17 Quay Pond	Historic NA burial
	19-WR-18 Unnamed	Historic NA burial
	19-WR-19 Sterling Campground	Unknown
	19-WR-493 E. Waushacum ROW	Late Archaic/Early Woodland
	19-WR-593 110 Landfill	Unknown
	19-WR-540 South Meadow I	Woodland (Ceramic)
	19-WR-541 Chase Hill	Unknown/possible burial
West Boylston	19-WR-185 South Bay Quartzite Quarry	Late Archaic/Early Woodland
	19-WR-274 Muddy Brook	Middle Archaic

2.4.2 Interpretation of the Archaeological Record

In reviewing the archaeological record of the Wachusett Watershed, indeed that of the entire Nashua River Basin, there are more questions than answers. The record is uneven at best, and is the result of amateur archaeological and collecting activities, rather than professional research. Indeed, as resource managers, we are in the tenuous position of establishing management guidelines, and evaluating project impacts, based on limited, rather than reliable, data. Nevertheless, the following generalized statements can be gleaned from the overall archaeological record of southern New England, as opposed to being specific to Wachusett.

The existing archaeological record documents a pattern of multiple, recurrent occupation of individual sites within most of Southern New England. Few sites have yielded artifacts from a single cultural/temporal period. Instead, artifacts from several periods have typically been recovered from sites. This suggests that some particularly well-sited locations were occupied, or otherwise utilized, more than once. Recurrent, though intermittent, occupation of a single site, sometimes over a period of several thousand years, appears to have been the prevalent pattern of prehistoric site development in this region.

Small groups, probably based on kinship, would have found the uplands most attractive for short-term occupation. Settlement is likely to have occurred on virtually any elevated, level and well drained surface that was located immediately adjacent to sources of fresh water, including the headwaters of ephemeral streams, springs, and small wetlands and ponds. Rockshelters and other natural overhangs, and locations with southerly exposures would also have been utilized.

It was common for groups to occupy large ponds such as East and West Waushacum, and other bodies of water such as Eagle Lake, Chaffin Pond, Maple Spring Pond and Quinipoxet Pond. Though some of these were altered during historic times, Native Americans may have utilized them, and archaeological survivals are possible. The site inventory for Wachusett also includes stream and brookside locations, and an incalculable number of sites would have been located along the main trunk of the Nashua River, and at its confluence with tributary streams. Even a rockshelter is represented among the types of locations occupied by local Native American peoples.

The analysis of sites throughout New England, and the statistical calculation of the information outlined above, has allowed archaeologists to define what they call ***Site Location Criteria***. It is these criteria that are the foundation of the Silviculture review discussed below.

2.4.3 Historic Resources

2.4.3.1 Archaeological

Significantly, there may be as many as six historic period Native American burials recorded within the Town of Holden: this is an unusually high number for a single community. Early historic accounts place the Nashaway sachem Nashawhonan's camp somewhere around the two Waushacum ponds, and during King Philip's War (1675 - 1676) the Waushacum ponds were an important gathering ground for the Nipmucks. A skirmish between the local Nashaways and colonial forces also reputedly occurred here. In 1974 members of the Massachusetts Historical Society's (MHC) Ekblaw Chapter, looking specifically for Nashawhonan's camp, undertook excavations (with MDC permission) on the bridge of land between East and West Waushacum. While they did in fact find a large site here, nothing recovered suggests Contact or Early Historic period associations. Rather, diagnostic artifacts from the

Middle Archaic, Late Archaic and possibly Early Woodland suggest occupation here from as early as 8,000 years ago to about 1,200 years ago.

To date an Inventory of Historic Archaeological Resources, similar to that completed at Quabbin, and has begun at the Ware Watershed, has not been undertaken for Wachusett. Therefore, other than identifying a few of the more obvious sites, a discussion of historic archaeological resources within the Wachusett Watershed is premature. Suffice it to say, when completed, such an Inventory will probably be similar to Quabbin's in terms of the range and type of sites that exist in the watershed, except undoubtedly the numbers will be considerably less at Wachusett. One would expect to find numerous farmsteads with former house and barn foundations, as well as the remains of other out buildings, schools, commercial and industrial sites. Indeed, along the Quinipoxet River alone, no fewer than thirteen mill sites can be identified on the 1870’s Beers Atlas alone. Other Atlases, such as the 1840 and 1890’s series will reveal additional sites. Whole villages, such as Harrisville, that were once bustling commercial and industrial centers, were removed from the landscape with the construction of the reservoir.

To date, the research needed to determine if anything has survived at these locations has yet to be performed. An informal, one day walkover in the fall of 1999 (Ranger Kovich and Archaeologist Mahlstedt) identified a number of interesting archaeological sites. These included the remains of an unnamed saw mill, G.R. Henry's Shoddy Mill, the Glen Woolen Mills complex, and several probable tenement houses for the Glen Woolen Mills, as well as the Hamlet Woolen Mills near Harrisville. The success of this one-day reconnaissance clearly attests to the potential survival of many interesting and significant archaeological sites that bear mute evidence of the rich historic legacy of the region.

It is presumed that at Wachusett, like Quabbin and Ware, there was differential treatment to existing buildings and structures during the construction of the reservoir. In some cases the superstructures were carefully razed and relocated to unthreatened locations. These actions often left well defined and well preserved cellar holes, mill raceways, barn foundations, etc. In other instances, buildings were knocked down and pushed in, and graded over, leaving no evidence except an occasional ornamental planting that seems curiously out of context.

A good example of differential treatment is the case of the Old Stone Church. The Old Stone Church is the only structure of the old center of West Boylston remaining on its original site. Originally the church overlooked a section of West Boylston that was inundated by the construction of the reservoir. Other nearby buildings and structures were razed or relocated. Today, the church stands alone, silently looking out over the waters of the Wachusett.

2.4.3.2 Buildings & Structures on the National Register of Historic Places

Development of a public water supply system for Metropolitan Boston began as early as 1825. With expanding populations and increased commercial and industrial demand for water, the Metropolitan Water Supply System constantly had to be upgraded and enlarged. The fourth stage of this growth came with the creation of the Metropolitan Water District (1895-1926), and after an exhaustive search, the South Branch of the Nashua River, just above the city of Clinton, was selected as the site of a new reservoir.

When the construction of the Wachusett Reservoir began in 1895, it was the largest project of its kind in the United States. Today, the many aqueducts, dams, dikes, reservoirs, shafts and pumping stations that were built to create Wachusett Reservoir and convey its water to Sudbury Reservoir #5, and then onto Boston are recognized as historically significant at both the local and national levels. Accordingly, in 1989, these engineering features, and many more, were listed on the National Register of

Historic Places as the ***Water Supply System of Metropolitan Boston Thematic Resource Area***. The listing includes the 91 individual buildings and structures that comprise the entire Metropolitan Water Supply System (excluding Quabbin, which was not yet 50 years old at the time of the listing). The Wachusett Reservoir watershed is represented in the National Register by the ***Wachusett Aqueduct Linear District***, which contains fifteen buildings and structures, and the ***Wachusett Dam Historic District***, which contains six individual buildings and structures (Tables 19, 20).

TABLE 19. WACHUSETT AQUEDUCT LINEAR DISTRICT

Property Name	Date(s)	Town(s)	Owner	Care/Control
Wachusett Aqueduct	1896-98	Clinton, Berlin, Marlborough, Northborough, Southborough	MDC	MWRA
Shaft #4 Chamber	1896	Berlin	MDC	MWRA
Metering Chamber	1897	Berlin	MDC	MWRA
Crane Meadow Road Arch	1897	Northborough	MDC	MWRA
Terminal Chamber	1897	Marlborough	MDC	MWRA
Northborough Rd Arch#1	1897	Southborough	MDC	MWRA
Northborough Rd Arch#2	1897	Southborough	MDC	MWRA
Assabet River Bridge	1897	Northborough	MDC	MWRA
Wachusett Lower Dam Open Channel	1896-97	Southborough	MDC	MWRA
Wachusett Upper Dam Open Channel	1896-97	Southborough	MDC	MWRA
Lynbrook Road Arch	1897	Southborough	MDC	MWRA
Flagg Road Arch	1897	Southborough	MDC	MWRA
Chestnut Hill Road Arch	1897	Southborough	MDC	MWRA
Hultman Aqueduct Shaft #1 Headhouse	1940	Southborough	MDC	MWRA
Hultman Aqueduct Diversion Dam	1940	Marlborough	MDC	MWRA

TABLE 20. WACHUSETT DAM HISTORIC DISTRICT

Property Name	Date	Town	Owner	Care/Control
Wachusett Dam	1900-06	Clinton	MDC	MWRA
Central Mass RR Bridge	1905	Clinton	MDC	MDC
Grove St. Bridge	1904	Clinton	MDC	MDC
Lower Gate Chamber and Powerhouse	1904	Clinton	MDC	MWRA
Lightening Arrestor Chamber	1911	Clinton	MDC	MWRA
Maintenance Building	1920	Clinton	MDC	MDC

2.4.3.3 Individual Listings and Properties Declared Eligible for Listing

2.4.3.3.1 Old Stone Church, West Boylston

The Old Stone Church, built by the Baptists in 1891, was barely completed when construction of the Reservoir began in 1895. Local granite from a quarry at Malden Hill was used to construct the English Country style building. Details of its ashlar construction are provided in the National Register

Nomination that was prepared in 1972. Abandoned, and unused, the church had fallen into a state of severe deterioration. A program of stabilization was undertaken years ago, and while it has largely arrested the principal problem, close inspection of its walls and joints reveals that it was not performed to particularly high standards.

2.4.3.3.2 Stillwater Farm, Sterling

Stillwater Farm dates to sometime in the 1790's, when Zebedee Reeding moved from Grafton. Like most New England farms, over the years it went through a succession of owners, and had grown appreciably: from the initial 50 acre Reeding purchase, to 153 acres when Samuel Howe purchased it in 1856. Sometime in the 1870's, Charles Chandler took possession of the farm. Several generations of Chandlers increased the holdings to 243 acres, moved the farm into commercial dairy and poultry, built numerous outbuildings such as hen houses, a corn crib, ice house, and 2 barns, and took over the adjacent Smith house.

Several intervening owners held title before Joseph A. Wronski, a Polish immigrant, assumed full ownership in 1925. Wronski and his five sons ran a typical New England farm, raising chickens, hogs, cows, and horses. They harvested gooseberries, and harvested timber and cordwood from a back lot. By 1971, with the sons employed in industrial jobs in Worcester, Wronski began to sell off some of his holdings, and in 1990, the MDC purchased the farm as part of its Wachusett Watershed protection program. This farm has been declared "eligible for listing" on the National Register, but is not yet listed.

2.4.3.4 Implications for Management for National Register Properties

The buildings and structures represented in the Wachusett National Register Listing represent an ensemble of significant technical, engineering, and architectural features, buildings and structures. Additionally, the Old Stone Church and Stillwater Farm, while more parochial in nature, nevertheless embrace the historic character of a past gone by. The designation of these properties to the National Register (or Declared Eligible for it) automatically places them on the State Register, thereby affording them a degree of protection from ill advised or uninformed development or alteration. Several statues have been passed that provide the Massachusetts Historical Commission, of the Secretary of State Office, with review jurisdiction of proposed projects on State and National Register Properties. MGL Ch. 9 s. 26-27c and Ch.254 of the Acts of 1988 establishes the authority of the MHC, outlines the review process, and clarifies who/what is covered under it.

The review process that the statutes establish is not meant to be tedious or obstructionist: to the contrary. Submission of a **Project Notification Form** (PNF) in a timely manner, and filled out entirely, with respect to detail, will result in a timely, and usually favorable response, provided that standard preservation guidelines are adhered to. Specifically, in considering any alterations to the historic fabric and/or grounds of a National Register, or State Register property, the ***Secretary of the Interior's Standards and Guidelines for Historic Preservation Projects*** must be followed. Failure to use the Standards in a good faith effort, and lack of detail and description in the PNF, will result in unwanted and unnecessary delays.

In its role as the "keeper" of the Register, the MHC can be of invaluable assistance to the MDC, as their trained staff of professional Historical Architects and Preservation Planners essentially become "in house" staff or "pro bono" consultants. They become part of the team, with both parties working toward a mutual goal. Their role is to see that a project has minimum adverse impacts to the registered property, and when accomplished, all parties benefit. Again, timely and thorough communication is the key to smooth and successful implementation.